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Big History and Sustainability

Duncan Blake Ross
Dominican University of California

This thesis, written under the direction of the candidate's thesis advisor and approved by the department chair, has been presented to and accepted by the Master of Arts in Humanities Program in partial fulfillment of the requirements for the degree of Master of Arts in Humanities. An electronic copy of of the original signature page is kept on file with the Archbishop Alemany Library.

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A Student Reflection

By

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ABSTRACT

The purpose of this paper is to provide a critical examination of Big History at Dominican and offer some retrospective suggestions for any possible future first year experience programs. I reflect on Big History texts, critical papers and books as well as my own experiences and interviews with others. My research and reflections suggest that Big History pedagogy failed to convey sufficient meaning and purpose to students. The actual value of the Big History pedagogy was compromised by confusing and unnecessary elements of the main text. I conclude that Big History pedagogy should culminate in sustainability studies. It is there students will find both meaning and practical application. An example is offered.

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Greta Thunberg

December 11, 2018

School Strike for Climate

INTRODUCTION

We live in bewildering times. Social media, fake news, internet trolls and hyper-partisan politics have distorted reality, confused and confounded the populace. Climate science, vaccines and basic moral, human decency have all been called into question. In short, human civilization is deeply in crisis. We seem asleep and collectively experiencing some deep, dark, disorienting dream.

Desperation spawns the need for unusual individuals with new voices and ideas. In our own government, we have seen the rapid rise of a young, multi-racial, multi-ethnic women's movement. But by far the most interesting to me is the global rise of a 15 year old Swedish girl named Greta Thunberg who decided to protest in front of Swedish parliament on August 20, 2018. Her climate activism has since reached global effect and "Fridays for Future" school strikes have seen numbers from 17,000 student strikers in the US to 150,000 in Australia and 350,000 in Paris (Wikipedia Contributors, "School strike for climate."). In less than seven months, her movement has gone from a single protestor to more than 1.7 million students in 128 countries (Carrington).

Interestingly, Greta's target included education as much as politicians. When people told her she should be in school instead of out protesting climate change, she pointed to the textbooks in her satchel. "I have my books here," she said in flawless English. "But also I am thinking: what am I missing? What am I going to learn in school? Facts don't matter anymore, politicians aren't listening to the scientists, so why should I learn?" (Crouch). Obviously, this message has broad appeal.

It was precisely this kind of global, scientific, social justice movement that attracted me to Big History; a new, holistic way of thinking. It was an educational program I believe Greta would appreciate.

In the preface to the seminal book of Big History, *Maps of Time*, David Christian wrote, "With the encouragement and support of Cynthia Brown, Dominican University of California in San Rafael (near San Francisco) has become the first university to introduce Big History as a foundation course for first-year students" (xxv). This was a big deal.

People around campus had high hopes for Big History and the first year experience at Dominican. I had approached Sister Carla Kovack, a notable Dominican Sister and educator at Dominican, and told her I was looking for a thesis idea. I expressed interest to her about the role of the Dominican Sisters at the University, but she dismissed the idea. "You should write about Big History," she said. She briefly explained the program and her enthusiasm was clear. I was hooked. I changed focus, began reading Cynthia Stokes Brown, David Christian and the other Big History books.

I was too old to take part in the First Year Experience but I was privileged to watch it happen. I attended the first International Big History conference in Grand Rapids, 2012 and I was honored to present a paper there. I attended the conference again when it came to the Dominican campus two years later. It was clear from the beginning there was a naturalist influence from the top that leaned towards materialism, reductionism and scientism, but that was a reflection of a larger movement in academia and culture which I ignored. I remained genuinely hopeful that something truly unique and profound was happening in education.

The director of the Big History First Year Experience (FYE) at Dominican, Mojgan Behmand, was full of optimism and confidence. "The Big History course sequence emphasizes global interconnectivity with the immense frame of reference as the foundation for recognizing and addressing the challenges of the 21st century," she said (Gardner). The FYE was a customized program based on the American Association of Colleges & Universities' LEAP Challenge. The AAC&U described the LEAP program: "Liberal Education and America's Promise (LEAP) is a national public advocacy and campus action initiative. LEAP champions the importance of a liberal education—for individual students and for a nation dependent on economic creativity and democratic vitality" (AAC&U, "About"). Essential ingredients of the AAC&U's vision were a robust set of Essential Learning Outcomes that students develop through a 21st century liberal education. These included:

1. Knowledge of Human Cultures and the Physical and Natural World
2. Intellectual and Practical Skills,
3. Personal and Social Responsibility,
4. Integrative and Applied Learning (AAC&U, "Essential Learning").

Behmand stressed the importance that each institution adapt the goals to their own culture and seek buy-in from stakeholders. She writes,

> First-Year Experience "Big History" is a one-year program that takes students on an immense journey through time to witness the first moments of our universe, the birth of stars and planets, the formation of life on Earth until the dawn of human consciousness, and the ever-unfolding story of humans as Earth's dominant species. In studying the evolution of human cultures, students engage with fundamental questions regarding the nature of the universe and our momentous role in shaping possible futures for our planet.
>
> We also determined the goals of the program are designed to promote:
>
> - recognition of the personal, communal, and political implications of the Big History story;
> - critical and creative thinking in a manner that awakens curiosity and enhances openness to multiple perspectives; and
> - development of reading, thinking, and research skills to enhance one's ability to evaluate and articulate understanding of one's place in the unfolding universe.
>
> ("Big History" 24-25)

Later in the book, *Teaching Big History*, Behmand describes assessment tools to measure the success of "essential learning outcomes" ("Assessing" 41). Among other measurements, polls indicated a positive impact with 80% of students responding that they thought about what they've learned in Big History courses and 72% responding that their Big History experience changed the way they see or understand aspects of the world ("Assessing" 47-48).

It seems to me, looking from the outside, from what I saw, what I experienced and what I read, that Dominican University faculty did everything they could to create, monitor, adjust and sustain an important educational experience. So what happened? Is 7-10 years the normal life expectancy of an educational initiative or did something go seriously wrong with this FYE?

Organizations from academia to corporations and government are good at looking forward but seldom spend much time in retrospective reflection. One is reminded of the joke about the six phases of a project which always ends with the hunt for the guilty, punishment of the innocent and rewards for those who were not even involved. Truly, large projects like the FYE at Dominican are too complicated to pinpoint exact fault lines and I will have no intention to name names and point to precise mistakes. My intention is to make general observations about the Big History program which might apply to any school. I want to offer a student's perspective on the Big History program at Dominican and reflect on possible reasons for its eventual demise. I will then offer what I think is the logical direction for any similar program and give an example of how I'd teach it.

Roadmap

- **Big History**: I begin by reviewing Big History as a foundation for a liberal education. I break down the elements of Big History and offer my views on what works and what does not work. My review of Big History will focus on: myth, thresholds-complexity-emergence and the epistemology of Big History.
- **Sustainability**: I will investigate sustainability and suggest it is an appropriate conclusion to a program like Big History at Dominican. I will provide a brief history, explain why Big History pedagogy should end with sustainability and how it creates meaning and

purpose. I argue that sustainability is embedded throughout Big History and serves as the unifying message.

- **Suggestion for Pedagogy**: Finally and in conclusion, I will offer a practical example of how Big History and sustainability could be taught together to complete the idea of a more complete and meaningful pedagogy. I introduce systems thinking as an essential tool for understanding Big History and sustainability. I then make a brief, concluding summary.

BIG HISTORY

One of the books that I still vividly remember from my childhood was a Scientific American publication entitled, *Power of Ten: A Book about the Relative Size of Things in the Universe and the Effect of Adding Another Zero*. It is mostly a picture book that takes the reader on a visual journey from subatomic particles to galaxy clusters. Big History, I think, plays on the same basic fascination. Who are we and what is our place in the universe? One of the founders of the Big History movement, David Christian, calls Big History a "modern creation myth" (*Maps of Time* 1). This idea stuck with me and since Christian is the presumptive leader of the Big History movement and *Maps of Time* is his seminal work, I decided to explore the idea of a "Modern Creation Myth" on several levels. What happens when you try to combine a very old idea like myth with modern & theoretical science?

Big History & Modern Creation Myth

Big History takes its readers on a scientific pilgrimage from the big bang to present day human civilization, step-by-step, through all these stages of creation not unlike an origin story or holy book. But can Big History replace our ancient myths and religious traditions with the sober reality of naturalist narrative? This seems to be the direction David Christian and other Big History writers are headed.

David Christian's suggestion that Big History could be a form of myth is also interesting because it suggests a bridge between science and the humanities. In fact, this idea is not new. It has been explored by many other scientists and scholars in the past fifty years. E.O. Wilson, Richard Dawkins, Thomas Berry, Brian Swimme and Mary Evelyn Tucker are just a few of the familiar authors who have written science-oriented creation stories loosely held together under a genre

that religious scholar Lisa Sideris calls the "New Cosmology" (*Consecrating Science* 1). Science, on its own, is meaningless. Theologian Ted Peters makes the point,

> world is abstractWhat about the question of meaning? What does the big bang story mean? As a scientific story, it has no meaning. Scientific stories are always meaningless, because the methods of science exclude meaningfulness at the outset. Even the story of the big bang cannot help but inspire in us a sense of wonder, awe, and appreciation....Even if cosmology prompts within us questions about meaning, and perhaps even about God's creative role, scientific cosmology cannot provide answers. (34)

What remained, certainly for me in preparation of this research, was some clarification about what "myth" entails. Is it possible to weave science and myth together in a narrative?

The traditional meaning of myth usually refers to a tale originating from oral tradition and passed on for generations as something embedded in culture that "...serves to unfold part of the worldview of a people.."("Myth"). The word is derived from the Greek word, mythos ("Myth") which means "story." A myth is a special kind of story which has emerged over time as a cultural artifact. The truth of myth often depends upon one's perspective. Of the many theories of myth, I want to contrast just two: the archetypal, monomythic theories of Joseph Campbell and Mircea Eliade and the functionalist ideas of Claude Levi Strauss.

Joseph Campbell said myth served one of four purposes: the mystical, cosmological, sociological or the pedagogical function. Campbell suggests modern people should focus on the pedagogical

function which offers advice about how to live our lives (*Power of Myth* 38). This is a kind of perennial wisdom.

Similarly, Mircea Eliade, a historian of religion, was also influenced by Jung and deeply interested in common religious symbolism across cultures. His theory of myth, similar to the Campbell's *Hero's Journey* was captured in his book, *The Myth of the Eternal Return*. The idea of eternal return is not to consider myth as empty ceremony or philosophy but to actually ***live*** myth as a transformative experience of rebirth. One might say that by 'living' the myths, one transcends the profane world and gains access to a sacred realm (Eliade 18). This is a realm of renewal, rebirth or restoration to an original, pure state.

Claude Levi-Strauss saw myth more as a primitive form of science. That is, for Levi-Strauss, myth was an expression of the same impulse modern humans have for science: to explain phenomena. The difference is that primitives found their world in concrete and immediate form, while for modern humanity, the world is abstract.

> For these men (i.e., primitives). . . the world is made up of minerals, plants, animals, noises, colors, textures, flavors, odors. . . .What separates the savage thought from (modern) scientific thought is perfectly clear-and it is not a greater or lesser thirst for logic. Myths manipulate those qualities of perception that modern thought, at the birth of modern science, exercised from science. (Segal 27)

There is a wide spectrum of views about myth, but I think these two opposing views capture the essence of the differences. Some see myth as a timeless story of an eternal quest for connection

to a sacred state while others see myth as rooted in the past, erroneous, superstitious and superseded by science. The views of Campbell and Eliade establish a metaphysics and direct seekers towards something ‘sacred’ and beyond the limits of secular science. Levi-Strauss saw this as folly. Science alone dictates reality.

A unique property of any view of myth is emergence. The narrative is greater than the sum of its parts. This is true of the mythopoetic tradition. Something greater emerges from the details, a meaning and purpose which is difficult to describe. Historian Peter Munz wrote, “The truth of a myth does not depend, in any case, on whether it is a true description of a single event located in space and time, but on whether people recognize themselves and their lives in it or not” (15). The essence of mythical thinking is the composition of a “Concrete Universal” (15). He used the example of Anna Karenina for emphasis.

> There is therefore nothing in the real world which corresponds to the composite product, the concrete individual. The figure of Anna Karenina, for instance, cannot be found in the world of Tolstoy's actual experience. There is no single woman of whom one can say that she is described in the novel. We must believe that countless experiences were welded together and that the observation of many years was distilled into the character of Anna Karenina. (14)

The concept of a “composite” I think is crucial here. Myth is traditionally composed of bits of truth and fiction. Science, history and fantasy are weaved together over time to create a whole which does not exist and never did exist in the “real world.” But together they create something recognizable and meaningful to people. Some critical whole *emerges* out of the mass. This

emergence is non-linear, not reductionistic and not scientific. There is no formula for myth. Surprisingly, I think, we will find that complexity, reviewed next, is built on similar concepts.

There are also important differences between mythological time and chronological time or cosmological time (Munz 15; Thapar 20). History occurs in a certain place and time. When David Christian speaks of Big History and the "chronometric revolution" and carbon dating as "...crucial steps towards a Big History..." (*Maps of Time* xxiv), he is talking about history, not myth. There may be superficial similarities between a sacred creation story and a scientific narrative about the big bang. In fact, these two evoke very different conclusions. Myth, for Eliade and Campbell, is a teaching story with a human being at the center of a journey about wisdom. For Levi-Strauss, myth is simply a surrogate for science. Another way to look at this is to consider how Christian validates myth. In *Maps of Time*, Christian claims, "the strongest claim we can make about the truth of a modern creation myth is that it offers a unified account of origins from the perspective of the early twenty-first century" (11). This completely misses the timeless appeal of myths and perennial wisdom. It may be possible to bridge science and myth. But science is not updated myth.

The introduction to *Maps of Time* begins with the question, "A Modern Creation Myth?" Christian states, "Creation myths are powerful because they speak to our deep spiritual, psychic, and social need for a sense of place and a sense of belonging"(2). If one used this simple definition of a modern creation myth alone, it would be difficult to distinguish Big History as myth from Big History as simple history. Christian goes further into the definition. He says he wrote *Maps of Time* to address the attached sense of loss in modern life which Emile Durkheim

referred to as “anomie,” a sense of not fitting in, which is “...an inescapable condition of those who have no conception of what it is they are supposed to fit into” (2). He continues,

> Taken together, these stories have all the power and richness of a traditional cycle of creation myths. They constitute what indigenous Australians might call a modern ”Dreaming"-a coherent account of how we were created and how we fit into the scheme of things. We found something else that most premodern societies have known: there is an astonishing power to any story that attempts to grasp reality whole. This power is quite independent of the success or failure of any particular attempt; the project itself is powerful, and fulfills deep needs. (3)

Christian states that, “...all accounts of reality are provisional” (*Maps of Time* Sapolsky11). He admits that his account may seem as “quaint and childish” in a few centuries as the traditional creation myths seem to us today (11). All knowledge systems are, to him, “maps of reality” and must solve problems whether they be “spiritual, psychological, political or mechanical.” He ends the introduction to *Maps of Time* with the following:

> In their day, all creation myths offered workable maps of reality, and that is why they were believed. They made sense of what people knew. They contained much good, empirical knowledge; and their large structures helped people place themselves within a wider reality. But each map had to build on the knowledge and fulfill the needs of a particular society. And that is why they don’t necessarily count as "true" outside their home environments. A modern creation myth need not apologize for being equally parochial. It must start with modern knowledge and modern questions, because it is designed for people who live in the modern

> world. We need to try to understand our universe even if we can be certain that our attempts can never fully succeed. So, the strongest claim we can make about the truth of a modern creation myth is that it offers a unified account of origins from the perspective of the early twenty-first century. (11)

To come to a conclusion on myth, I would say there is a narrow view of meaning employed in Christian's explanations and justifications for Big History as myth. It is narrow not only because his narrative limits its scope to contemporary science but because he simply cannot envision a reality beyond present day science. He does not seem aware of the possibility that fictional elements of myth may be the most meaningful. I don't think he intentionally demeans religious people when he speaks about how his views may seem as "quaint and childish" to people in the future as traditional origin stories seem to him now. He does not seem to know how to engage anyone who does not make science their de facto reality.

Big History - Thresholds, Complexity and Emergence

Big History has been described as a grand narrative (Christian, *Maps of Time* 9-10), a grand unified theory (Christian, "The Evolution of Big History" 20), a theory of universal Darwinism (Christian, "Universal Darwinism and Human History" 61-63) and an evolutionary epic (Sideris, *Consecrating Science* 1). The idea of bringing science and history together is neither new nor peculiar to David Christian and fellow big historians. I've mentioned the "New Cosmologists" like E.O. Wilson, Richard Dawkins, Thomas Berry, Brian Swimme and Mary Evelyn Tucker. Peter Turchin and his idea of "Cliodynamics" is yet another. But there are a few unique and consistent organizational concepts behind Big History.

Thresholds of Increasing Complexity

Big History organizes our universal evolution story into an hierarchy of levels of complexity separated by thresholds. Thresholds are tipping points or boundaries between one system of interactions and the next. The hierarchy is stacked in increasing levels of complexity.

Examples:

- A large cloud of hydrogen and helium gas with gravity pulling the gas molecules together to form a star.
- A system of planets revolving around a star driven by the gravity, heat and light of the star.
- A planet not too close or too far from the star that can have liquid water and maintain an atmosphere to sustain life.

Big History pedagogy has identified a total of 8 thresholds of increasing complexity that represent various levels and an evolutionary scheme to our universe from the big bang to the present day ("What is Big History?").

1. Big Bang
2. Star Formation
3. New Chemical Elements
4. Earth and Solar System
5. Life on Earth
6. Collective Learning
7. Agriculture
8. Modern Revolutions, Industrial Age, Technology, Anthropocene

Is there a specific science behind these divisions? Or is this more of a general historical or mythological hierarchy? It is unclear to me. One might say the organization is logical and yet somewhat arbitrary with infinite other possibilities for additional or different demarcations. This eight building block hierarchy that evolves from the origin of the physical universe to our current human civilization is built, we are told, upon levels of increasing complexity.

> In Big History and the Future of Humanity, Fred Spier has built on an earlier work of his and on the work of Eric Chaisson to produce what is currently by far the most sophisticated attempt to construct a thematic scaffolding for Big History. He carefully links the idea of increasing complexity with the associated themes of energy flows and the idea of goldilocks conditions-the notion that complexity can increase only under very special conditions and within quite exacting ”boundary conditions." Here are broad theoretical ideas that can help give greater depth and coherence to the story told within Big History. (Christian, *Maps of Time* xxiv)

It is said that more activity and change occurred in the first second of the universe than in all the billions of years since (Krauss). Between the first threshold, which oddly does not seem to be contingent upon complexity and the second threshold, many things occur which also may or may not depend upon complexity. The united fundamental forces of electromagnetism, weak nuclear force, strong nuclear force and gravity all divide and have their own effects. The universe of space and time is created and expands faster than light speed. Energy and matter are created. Is complexity involved in any or all of the “sub-thresholds?” Why or why not? It is unclear. I am only offering these examples to make the case that thresholds are a somewhat random or arbitrary concept. It can be confusing, I believe, in history, to think about what happened in the

past and what necessarily happened and what must follow. Does the universe or any segment of humanity truly have a *destiny*? It is unclear, but science would most likely say, 'no.'

Complexity

An even more important and fundamental question is *what is complexity*? How does it work? Is each "threshold" independent and composed of a closed system or is there some kind of top-down or bottom-up causality in this chain of being? Is this causal narrative single or multi-directional? Perhaps the laws of complexity will explain how thresholds work. Is this hierarchy really a *holarcy* (Koestler 102-103) where every step in creation is both an autonomous individual and a part of the *Whole*? To answer these and many other questions, we need to investigate complexity. Does complexity explain some meaning about the universe or our being?

> We are a generation or two into thinking about (complexity and emergence) and it is incredibly hard to think about. Most of the work that I do and my peers do is reductive stuff that is very limited. I don't understand how to think about this stuff in this other way and odds are, you guys are not going to be good enough at it either. You are good enough that you were the first generation growing up to know if you want to find out if you are going to like a movie or not, you don't need to have somebody with expertise and a label on their forehead, you don't need critics anymore, you have bottom-up systems (eg crowd-sourced reviews, etc.). You guys are the first generation growing up thinking in that way. What is a consequence of that? You are beginning to get better at this stuff and my guess is that it is not until your grandkids that we have people thinking so much in

> emergent systems that we'll finally be able to figure out what the brain is doing. (Sapolsky)

Stanford biology professor Robert Sapolsky stated in this 2010 lecture the counter-intuitive idea that complexity works best when the building blocks of complexity are simple, when they have clearly defined rules. He gave an example by comparing small and large ant colonies. Some ants have simple roles and their behaviors are not very adaptable. But add thousands or millions of these same individuals together and a very adaptable form of intelligence *emerges*, a swarm intelligence (Singer). More complicated ants with more adapted individual behaviors and specialized roles, surprisingly, do not typically show swarm intelligence and tend to live in smaller colonies (Sapolsky). Sapolsky asks, "How do we understand these counter-intuitive, non-deductive phenomenon?" This, I believe, is an important question asked by Big History.

History of Complexity

The roots of complexity theory probably go back thousands of years. Greek atomists Leucippus and Democritus hypothesized about a fundamental "atom" of indivisible quality upon which all material was assembled (Berryman). These proto-scientists attempted to explain a natural world free of the intervention of the gods. Epicurus and these earlier atomists described how the visible world could exist in alternating states of instability and change, growth, development & decay. Even stone and metal would, over time, yield to weather and water and lose their form. They asked, how is the world not already in a complete and permanent state of decay? The answer must be that these forms are composed of tiny immutable objects called atoms and these objects have a certain bias or tendency to "swerve" (attractions and repulsions) to create larger forms. And this is how the material world exists and is continuously recreated. Thus, though this is just

a brief sketch, they introduced naturalism and determinism which are important philosophical foundations of the materialist philosophy.

Plato and Aristotle both contemplated what made the whole greater than the sum of the parts (Aristotle). Plato discussed *eidos* or "form" while Aristotle suggested there is a quality of "thingness" or *ousia*. These are early ideas of the concept of "emergence" which is central to complexity (Plato).

So the idea of complexity is not a new thing. The philosophical ideas behind complexity have been around for many centuries. But the last century has produced a paradigm shift in science which humanity is still attempting to adapt. The major milestones include quantum physics, big bang cosmology, an expanding universe and the ability to gather and process huge amounts of data by computation. These factors have put pressure on the scientific and philosophical models of classical physics, reductionism and determinism (Corning 20-22).

1940-1960

Macy Conferences held by the Josiah Macy, Jr. Foundation in New York City in the 1940s and 1950's had the putative purpose of improving education in medical science but had an important impact on other sciences and proved to be groundbreaking in the field of cybernetics. These interdisciplinary meetings generated important early work in neural networks, systems and information theory and self-organization that proved to be foundational in complexity science (Abraham 2; Alhadeff- Jones 69).

1960-1980

Developments in the 1960s and 1970s included progress in Artificial Intelligence led by Herbert Simon and Alan Newell (Alhadeff- Jones 72), John von Neumann and Stanisław Ulam made progress in cellular automata (Alhadeff- Jones 75) which John Horton Conway applied to create the Game of Life in 1970. The game was a simple but effective and popular visual demonstration of evolutionary rules displayed in real time (Yu & Reevesman). In 1977, Ilya Prigogine won a Nobel Prize for his work with dissipative systems which describe how thermodynamically open systems operating far from thermodynamic equilibrium in an environment can self-organize and sustain organization over long time periods (Alhadeff- Jones 73-74). This is one of the engines that many researchers believe drives complexity.

In 1972, meteorologist Edward Lorenz gave an address to the AAAS entitled, *Predictability: Does the Flap of a Butterfly's Wings in Brazil Set Off a Tornado in Texas?* He introduces the work he had been focused on in the 1960s on nonlinear dynamics and "chaos." The so-called "butterfly effect" spawned from his address describes how models of complex dynamic systems like weather are extremely sensitive to initial inputs. Determinism, up to this time, had always been associated with predictability. He showed with deterministic chaos that small changes in inputs could result in large and unpredictable variations in outputs (Dizikes).

Another groundbreaking movement in the 1970s involved chaos and "fractals." Benoit Mandelbrot formalized the structure of an "object which was chaotic in space" and called them fractals. A more clear definition of fractal might be: "a geometric figure that does not become simpler when you analyze it into smaller and smaller parts." Fractals are a visual reflection of

chaos. Chaos and fractals are nonlinear deterministic phenomena (Baranger 4). Chaos is not synonymous with complexity nor is chaos a subset of complexity. They are related concepts because they are both nonlinear dynamic models. The crucial difference is chaos is *deterministic* (a static formula is applied to input to get output) while complexity is *indeterministic* and it is unclear if output values could be calculated from input or how (Rickles & Hawe 934).

The last major topic relevant to complexity that occured in this time period was the idea of Autopoiesis, a system capable of reproducing and maintaining itself. The term was introduced in 1972 by Chilean biologists Humberto Maturana and Francisco Varela in their book, *Autopoiesis and Cognition*. Autopoiesis is an important theory because it is a dynamic complex model originally intended to envision how biological cells reproduce but caught the attention of scholars who used the model to scale up to larger biological and social phenomena using the same descriptions (Alhadeff- Jones 74). Artificial life games are one example.

1980-On

The third wave of complexity-related research continued with a noted focus on complex adaptive systems like those defined in *Autopoiesis*. In 1984, the Santa Fe Institute, the first research institute dedicated to the multidisciplinary study of complexity science and complex adaptive systems, was established in Santa Fe, New Mexico. Many of the founders were physicists already doing research in Los Alamos National Laboratory near Santa Fe and many had been involved in the Manhattan Project (German).

The goal of SFI is to provide interdisciplinary research on complexity and to "...endeavor to understand and unify the underlying, shared patterns in complex physical, biological, social, cultural, technological, and even possible astrobiological worlds" ("About SFI - What is complexity?"). The Institute has attempted to preserve a pure research environment free from binds of academic or governmental agendas. SFI often holds free public lectures, publishes its research freely and offers online classes on subjects relevant to complexity. The rules of chaos are well understood, but the math and science behind complex adaptive systems (or complexity science) are still thought to be at early stages (Baranger 9). SFI has tried to focus on this by providing, "...freeform transdisciplinary collaboration....a refuge for brilliant scholars to interact in an environment that was free from boundaries" (German).

In the past 60-70 years of complexity related research, some common themes are notable. The research from the very beginning has been multidisciplinary, interdisciplinary and transdisciplinary. In line with the requirement to avoid narrow disciplinary focus, dynamic systems researchers are mostly non-reductionist (with notable exceptions like Murray Gell-Mann). And while there are many different ideas about complexity science, there are some common terms used by many researchers which are important to know:

Important Precursors to Complexity

- Cybernetics - Norbert Wiener 1946. Closed Systems Science.
- General Systems Theory - Karl Ludwig von Bertalanffy 1946. Open Systems Science. General Systems Theory is the foundation for Systems Thinking.
- Information Theory - Claude E. Shannon 1948

Elements of Complexity

- Complexity
- Tipping Point - Threshold
- Emergence

Definitions of Complexity

There is no consensus definition of complexity. Former Santa Fe Institute researcher and professor Melanie Mitchell puts it bluntly:

> But how can there be a science of complexity when there is no agreed-on quantitative definition of complexity? I have two answers to this question. First, neither a single science of complexity nor a single complexity theory exists yet, in spite of the many articles and books that have used these terms. Second, as I describe in many parts of this book, an essential feature of forming a new science is a struggle to define its central terms. Examples can be seen in the struggles to define such core concepts as information, computation, order. and life. In this book, I detail these struggles. (13-14)

As Mitchell points out, there is currently no quantitative scientific definition to measure and experiment with complexity but fortunately, there are plenty of qualitative definitions. The following is a brief sample of opinions about the definition of complexity which should give a good sense of how fluid the discipline of complexity science is.

> ...a system in which large networks of components with no central control and simple rules of operation give rise to complex collective behavior, sophisticated information processing. and adaptation via learning or evolution. (Mitchell 13)

> Roughly, by a complex system I mean one made up of a large number of parts that interact in a non simple way. In such systems, the whole is more than the sum of the parts, not in an ultimate, metaphysical sense, but in the important pragmatic sense that, given the properties of the parts and the laws of their interaction, it is not a trivial matter to infer the properties of the whole. In the face of complexity, an in-principle reductionist may be at the same time a pragmatic holist. (Simon 468)

> Complexity arises in any system in which many agents interact and adapt to one another and their environments. These interactions and adaptations result in evolutionary processes and often surprising "emergent" behaviors at the macro level. Complexity science attempts to find common mechanisms that lead to complexity in nominally distinct physical, biological, social, and technological systems. (“About SFI”)

What I see in common with these definitions is the desire to understand open systems as hierarchies of transactions between many agents which give rise to something new, adaptive and self-organizing. The range of these hierarchies lie between total order and total disorder (the so-called goldilocks or boundary conditions). These systems are non-linear, non-reductive and non-deterministic. This means the whole that is often greater than the sum of the parts through emergent behavior is completely unpredictable given our current understanding of the parts of the systems. In short, complexity is something we don’t completely understand. Like wave-

particle duality, complexity is a marker that signifies the border of our understanding about observable phenomena. Important complexity science precursors like General Systems Theory, more popularly known today as Systems Thinking, are still relevant while we wait for complexity to become more advanced.

Thresholds & Tipping Points

Thresholds or tipping points represent the boundaries between regimes or levels in a complex system hierarchy. In *Map of Time*, Christian said,

> One of the most familiar examples in daily life is the transition that takes place when water turns into steam. Water is heated, and for a time all that seems to happen is that it gets warmer. Change occurs gradually, and we can watch it happening. Then, abruptly, a threshold is crossed; something new is created and the whole system enters a new phase. What had been liquid becomes gas. Why should a threshold occur at this particular point, in this case at 100°C (at sea level)? Sometimes we can explain transitions from one state to another, and the answer generally turns on a changing balance between different forces-between gravity, pressure, heat, electromagnetic forces, and so on. Sometimes we simply do not know why a threshold is crossed at a particular point. (25)

> As far as we know, no science we possess could have predicted the qualities of waters from the properties of hydrogen and oxygen or determined that when they combined to form H_20, there would be state changes from solid at less than 0°C to liquid to gas at more than 100°C. Zero and one hundred represent simple examples of thresholds. (Luisi 231-233)

Emergence

In the above example, 0°C and 100°C represent thresholds. The properties of the water molecules across these specific thresholds are examples of *emergence*. There is no universally agreed upon definition of emergence but the general idea is *the whole is more than the sum of the parts*. Emergence describes the transition from one set of properties to a new set of properties. Emergence is a property of complexity but emergence does not require complexity. The water example above is neither chaotic nor complex. Under standard atmospheric pressure, water always produces emergent properties and is completely deterministic.

Threshold-Complexity-Emergence Questions

With these varying definitions, we have enough to begin asking some difficult questions:

- Are the emergent properties of water (as gas, liquid and solid) an example of complexity?
- How do you measure complexity? Is Chaisson's energy rate density a measure of complexity or simply a property of complexity? We know that life at threshold 5 consumes more energy than a star on a per gram of matter basis. But does this tell us really about complexity shared (supposedly) between stars and living organisms? (Chaisson, "Energy Rate Density")
- Is complexity always a pyramid where lower levels of complexity are required to build a foundation for higher levels? (This is not the case in evolution and sometimes simple biological organisms evolve from more complex ones)
- If complexity and emergence are not reductive, bottom-up processes and the properties of hydrogen and oxygen don't describe water molecules properties any better than stars,

planets and elements (thresholds 2,3 & 4) explain or predict life (threshold 5), then how do we understand the need for an hierarchy?

And so on. There are no complete answers for these questions since complexity and emergence are vague scientific terms for phenomena scientists don't entirely agree upon nor understand. It would seem to some scholars that somehow the creation of stars and stock markets are connected, but how? Energy Rate Density? Does complexity make life meaningful or does it prove it is random and meaningless?

Christian on the Colbert Report

David Christian: *What the course does is it teaches you the whole history of time. It gives you a sort of map of time and space like an origin story. And that means you can place yourself in the universe and in the whole of time and space.*

Stephen Colbert: *I've always assumed that I'm at the center of the universe and that everything is turning around me. I believe that Galileo discovered that.*

David: *Of course you're at the center of the universe. And the person who tells the story is at the center of the universe - always. But you need to place yourself in that large map. And if you can place yourself in that large map that gives you a sense of meaning; of where you are, of how you came to be and of what things you can do; what possibilities are available to you.*

Stephen: *Well, David, what is the meaning of life?*

David: *The meaning of life? ... ok, um ... here's the quick version….13.8 billion years ago the universe appears. It's that small (makes a very small circle with his fingers). Everything in the universe is in that tiny thing. It's incredibly simple. No humans. No planets. No elements. Then over 13.8 billion years - one by one - new, more complex things appear. Stars appear. Planets*

appear; living organisms, at least on this planet, and then eventually us, the weirdest organisms of all. So, that's a wonderful story about how we got to be here.

Stephen: *That's the events of life. That's not the meaning of life.*

David: *The meaning is like a map. If you have a map it tells you where you are. If you know where you are, you know where you can go.* (Comedy Central)

Meaning

I don't sense a great deal of difference between Christian's explanation on the Colbert Report show above or this explanation in *Maps of Time*. The idea that a map is the meaning or that a string of scientific events holds meaning seems as unclear to me as it apparently did to Stephen Colbert. I don't know if David Christian has a clear epistemology of Big History. I have read many of Christian's books and papers and I have never seen him adequately clear this idea up. In his latest book, *Origin Story*, Christian refers to the same ideas as found in *Maps of Time*. A sense of *anomie* plagues humanity due to our reliance on religious, ethnic or nationalist identities. Science, he writes, unites us (ix-x).

This paper does not contain space to consider the scope of epistemological possibilities for Big History. It appears clear to me that science, by design, holds no meaning (in the sense of bestowing, purpose, legitimacy or significance to one's existence). This is by design. Science, as an antithesis to theology, does not argue what should be. It is designed to simply and objectively describe what is.

Myth, Complexity & Meaning: A Discussion

I have investigated myth, complexity and meaning after reading *Maps of Time* and I am still not clear what Big History is. Some ideas are clear. Christian said, "I intend this book to contribute to the larger project of constructing a more unified vision of history and of knowledge in general" (5). I accept this idea even if some professional historians may find that idea objectionable.

Big History intends to be interdisciplinary which means it also receives criticism from specialists in other fields. The idea that the big bang and the formation of gas, stars and planets naturally led to life, human beings and civilization suggests a certain historical anthropocentrism. This has been one of the major criticisms of Big History by scholars (Hesketh 196) (Chaisson 31). It is clear that the appearance of humanity was contingent upon all of these earlier events but that is incidental and not necessarily "historical." Chaisson makes the point that while humanity has appeared in the universe, it is just as likely if not more so that humanity (as we know it) was unlikely to appear ("The Natural Science" 6).

My goal in writing this paper was to select a few topics central to Big History that I found confusing, review them, make suggestions and offer alternatives and additions to make Big History more meaningful. Myth and Complexity were examined as they apply to Big History. They represent opposite ends of the academic spectrum from humanities to science and both are extremely subjective and require effort and choices in perspective to clarify. The awkward, intended combination of science and myth is one of the primary stumbling blocks for Big History.

My conclusion is myth is its own topic and has its own requirements. Myth has no obligation to strive for scientific clarity. Myth has survived for thousands of years by reaching beyond our perceptions of reality into the fantastical to suggest what *could* be, not what is. Myth is about wisdom and aspirations, not perceptions of what is. Why David Christian, and those before him, decided to combine myth and science remains unclear. Perhaps it was a distaste for religion and a desire to enlighten students. Perhaps it was driven by a belief that humanities and science should be united in some sort of "consilience." Regardless, it remains an area of confusion. Likewise, Complexity is used like a *MacGuffin* (Springer) in the Big History texts. Complexity is clearly something important but non-specific that drives the plot like a mysterious suitcase in *Pulp Fiction* or an ancient figurine in *The Maltese Falcon*. This is not a good model of science for students. I was left with the nagging feeling that I did not understand something fundamental to Big History. It took a lot of time and research to discover complexity was not really ***something*** yet.

There are many aspects of myth which place it in direct contradiction to the way it is used in Big History. A myth, for example, is not typically something authored by one individual. Myths are (like complexity) *emergent* in at least two important ways. First, myths *emerge* over time and in unpredictable ways. They are usually rooted in an ancient and often unspecified time and they are passed between many individuals over time with no particular author or original source. Myths are often oral traditions and the content is flexible to time, place and circumstance. Myths evolve in accordance with their environment.

The second way myths are emergent is an extension of the first. Myths are a composite of facts, fictions and allegories which are greater than the sum of the parts. Myths would be compromised if they were grounded in scientific fact or theory. Creation myths especially, attempt to reach back to primordial times and connect human consciousness with a state of unity. It reaches towards the ineffable. The meaning of myth is very specifically metaphysical. Indeed, after my review, I think the most important and most potent aspect of myth is this theological aspect of myth, expressed by Joseph Campbell in the *Hero's Journey* and Mircea Eliade in *The Myth of the Eternal Return* that we have examples of "concrete universals" that transcend time, culture and religion and speak to the essence of humanity. It is also important to note myths do not generally project forward in time (like science often is), they are retrospective in nature and connect the living with their ancestors and a primordial past.

There is little reason to support the idea of Big History as a modern creation myth. Christian recently released *Origin Story: A Big History of Everything* which avoids the usage of the word "myth." Perhaps it is best to think about Big History as an evolutionary epic. Christian's predecessor and inspiration, E.O. Wilson, described many of his books as evolutionary epics (*On Human Nature* 201). If there is some crisis of *anomie* referred to by Christian (*Maps of Time* 2), I am not sure Big History adequately addresses it. Science alone may not be the solution to a rootless, modern, global civilization suffering from *amythia*. Choices in *Maps of Time* were left undecided. In the final analysis, myth should be left out of Big History. It makes the book confusing while not delivering on the intended promises of creating meaning and purpose.

Concerns about Complexity

Complexity like myth is surprisingly elastic and currently holds no particular definition. The sense I got from reading Robert Sapolsky and Melanie Mitchell is that we are years or possibly decades away from really understanding complex phenomena. Complexity, also like myth, is an emergence of unity over multiplicity, something unique, unexpected and greater than the sum of the parts rises from its composite elements. For this reason, we should be cautious to draw too much science from complexity. It may represent a new way of thinking about science but there is no consensus about what that entails.

This chart (see table 1.) from *Big History: Between Nothing and Everything* (Christian, Brown & Benjamin) is a particularly grievous and misleading example of simplifying complexity. Life Threshold 5, it suggests, is a simple matter of adding complex chemicals and energy to get complex molecules which form reproductive cells in liquid medium. This is pseudoscience. As matter and gravity create stars and plants, so complex chemicals, liquid water and energy create life? I'm afraid it is not that simple. This is not a good example of science. Christian does a disservice to science and misleads students when he presents naturalist scientism as established evolution. There is something deceptive about this I find unappealing.

Eight Thresholds of Increasing Complexity (*cont.*)

THRESHOLD	INGREDIENTS ►	STRUCTURE ►	GOLDILOCKS CONDITIONS =	EMERGENT PROPERTIES
4. PLANETS	New chemical elements and compounds in orbit around stars.	Diversity of materials bound together gravitationally and chemically into large balls of matter normally orbiting stars.	Increasing abundance of heavier elements in regions of star formation.	New astronomical objects with more physical and chemical complexity and potential to generate even greater chemical complexity.
5. LIFE	Complex chemicals + energy.	Complex molecules bound together chemically and physically in cells capable of reproduction.	Abundant complex chemicals + moderate energy flows + liquid medium such as water + suitable planet.	Metabolism (capacity to extract energy); reproduction (ability to copy themselves almost perfectly); adaptation (slow change and appearance of new forms through natural selection).

Table 1 Two Thresholds of Increasing Complexity from the Big History Project.

While myth and complexity share some surprising similarities, there is one aspect that remains a key difference. Myth as a sacred (ideology) is concerned with finding power (agency), healing, meaning and purpose by returning to the Source. Complexity, as a reflection of science, is more concerned with reaching out towards the future, new discoveries and new territory. Myth, at least the Campbell sense of myth, is cyclic while complexity, like science and history, in the western sense, is very much linear.

Maps & Meanings

Another related and flawed idea in *Maps of Time* is that the "map is the meaning" mentioned from the Stephen Colbert interview above. A map is simply a map and Christian's attempt to justify how maps relate to meaning is unconvincing. Christian's suggestion that Big History

provides a map that tells individuals where they are, how they got there and where they can go next strikes me as hollow. I fail to see how personal choices arise from an approximate evolutionary backdrop? The idea is vague and too general to be genuinely useful, especially when heralded as the big idea behind Big History by its author. From a broader, more philosophical perspective, Big History's map might lead one to observe that humanity is a small speck in a huge, ancient universe. How unlikely it would seem that we find ourselves alive on this rock. Is it totally random or do the long odds against us suggest some purpose? There are some who may find the triumph of the human spirit over our random, meaningless existence a comfort. This view, to me, seems as speculative as one who finds divinity and design in the evolving universe.

History professor David Blanks made the point about maps and meaning in the first issue of the Journal of Big History. Blanks commented on Christian's idea that the "map is the meaning" of Big History. "Meaning as a concept only has validity in a metaphysical sense. From this perspective, the meaning of human existence cannot be discovered using modern science" (59).

Ian Hesketh restates this conflict between myth, science and meanings through the lens of anthropomorphism. "Big historians seem to think that by accepting the mythological nature of their endeavor to write a grand cosmic sweep of scientific origins, they will be establishing deep meanings that are themselves based on what the science tells us happened" (196). But as mentioned previously, these are the events of cosmic evolution, not the meanings. Hesketh continues, "Indeed, like any myth, Big History's deep meanings are not inherently derived from empirical observations but from its anthropomorphic projections of an idealized cosmic world"

(196). It is inevitable that humans are likely to anthropomorphize their thoughts and discoveries whether their perspective is science, myth or anything else. This is one of the unavoidable limitations of being human. But, we should recognize when we do this, we step outside the discipline of science.

There appears to be something of an irresolvable tension and dilemma between science and myth with respect to the Big History narrative. If the narrative is truly scientific, then the anthropocentric and anthropic aspects of Big History's "compelling, yet provincial, narrative..." (Chaisson, "The Natural Science" 2) should be dropped. If a true universal and scientific perspective is taken, the price seems to be any pretense at meaning or purpose for human beings and Big History loses its mythical quality. If the mythic quality is preferred over the science, the narrative loses the very legitimacy lent to it by being "scientific." A schism exists. A choice has to be made. But thus far, none has been made. It is a critical dilemma.

A key aspect of myth is ritual. What activates this story? What personal action and engagement embodies the message of Big History? What actualizes the pedagogy and makes it meaningful, strikes awe or wonder for the individual? Lisa Sideris ("To know the story is to love it'." 206-207) and Rich Blundell have both made this point in their reviews.

> ...ask yourself: How much of what is scientifically known can I also claim to have been personally experienced? There are, of course, multiple ways of knowing. But how much do we, the researchers, teachers and writers of Big History, actually live the familiar concepts of physical, biological, social and cerebral emergence

> that drive the Big History curriculum? I wonder about the consequences of our vast accumulation of intellectually known yet not lived knowledge. (Blundell 1)

Sideris has been tracking the movements she thinks preceded Big History and those that followed, all under the moniker of the "New Cosmology." Sideris, long inspired, she writes, by Rachel Carson and her focus on "wonder," finds a kind of surrogate religious wonder in the new cosmology which she considers flawed (*Consecrating Science* 3).

> Profoundly impoverished forms of wonder have come to inhabit a significant segment of contemporary discourse in religious environmentalism, science and religion, and a handful of other disciplines caught up in a kind of creeping scientism. These questionable forms owe some of their currency to arguments aggressively disseminated by a few prominent (one might say, celebrity) scientists and science writers-notably, Richard Dawkins and E.O. Wilson. In setting the contentious terms and tone for much of our contemporary science-religion discourse, they have also strongly shaped-I would say, warped-our understanding of wonder. (*Consecrating Science* 3)

I agree with Sideris. I have read Dawkins, Wilson and Christian and find a common theme, a sort of evangelical atheism running through much of their writing in this area. I see no pedagogical advantage in accepting this nor turning a blind eye to its advocacy in educational texts like *Maps of Time*. Sideris asks, "How did we arrive at narrowed and impoverished articulations of wonder, and what, more precisely, do we stand to lose when we accept their terms?" (*Consecrating Science* 10). This is a reasonable question.

If we put the atheist, naturalist agenda aside and just look at the science, Sideris makes the case that “consilience” (Wilson) and other forms of grand reductionism to physics and chemistry are bad science. Christian and some of these others want to construct a global evolutionary epic on a consensus science narrative that does not exist. Every threshold of complexity in Big History has dissenters in science who see physics, chemistry, biology, etc. differently than the way it is laid out in *Maps of Time* (Sideris, "To know the story is to love it 210’). It is misleading to readers to suggest there is one science narrative.

Even at the Santa Fe Institute, an important world hub for complexity science, there are influential scientists that cling to reductionism and determinism (Murray Gell-Mann) and those that reject it (Kauffman 26-27). There are fundamental differences in the same think tank. This is a healthy and constructive environment for theoretical science but a poor foundation for teaching interdisciplinary history in higher education.

And finally, even if there *was* a consensus about the science of Big History, Robert Bellah is right to point out this does not invalidate other creation myths, origin stories or religious beliefs (47). To suggest or privilege science as true or reality seems to suggest all other, non-scientific narratives are therefore false or fake. This seems like a bit of a presumptuous, a false dichotomy. The “loss” Sideris alludes to above by accepting these grand narratives, I think, is the greater perspective that science is a powerful but limited lens to view reality. There is no need for Big History to suggest students need to choose between science and religion (Sideris, "Science as sacred myth?" 51-51). Dominican faculty may have been surprised, but I was not surprised to

read that Mojgan Behmand and faculty determined, "...students perceived a dichotomy between science and religion that we faculty did not subscribe to" ("Assessing Big History Outcomes" 46). Scientism was a clear issue from early on.

Additional Issues

There are many points remaining which one could find to criticize Big History. It constructs a reductionist, deterministic universe utilizing a non-reductionist, non-deterministic model (increasing levels of complexity) which is contradictory to its own narrative. There is no consensus about the reductionist science nor the complexity science upon which the model is built. Upward and downward causality among the thresholds of increasing complexity are contentious subjects (Emmeche, Køppe & Stjernfelt). The anthropic principle and the anthropocentrism that the Big History narrative is hinged on, according to some (Chaisson 3), leaves Big History open to criticism by "serious science." And so forth. No paper is big enough to contain all there is to criticize or praise Big History. I have tried to take note of some of the more glaring offenses found in myth, complexity and Big History's meaning.

Big History should remove myth from the pedagogy. It is unnecessary. It might even be more honorable to acknowledge myth as something separate from Big History. Something like non-overlapping magisteria of Stephen J. Gould. Thresholds of increasing complexity could be replaced with just evolutionary thresholds or levels of creation. Occam's razor applies. Remove the vagueness from Big History to reveal the essential qualities. Now I want move from criticism to a review of the potential of Big History and offer some constructive suggestions for future development.

Big History's Potential

What I find so appealing about Big History is the chance to understand what appears to be a re-emerging paradigm. Atomism, Democracy and Evolution all hinted at the phenomena and problem of understanding complexity and emergence. Unity in multiplicity is an old idea with a long history, but perhaps the time is right and the tools are emerging to solve this riddle.

Big History is unique and a desirable academic subject for many reasons. It provides an overview of disciplines and shows how they interrelate. It provides the foundation to meet the education outcomes of a liberal education which Mojgan Behmand enumerated earlier in the paper. It introduces deep epistemological and ontological questions in a relatable context. Big History challenges many of the core assumptions of the past from theology to science. But my contention is, until we turn to sustainability, Big History's true purpose remains hidden.

SUSTAINABILITY

> Sustainable development cannot be achieved by technological solutions, political regulation or financial instruments alone. We need to change the way we think and act. This requires quality education and learning for sustainable development at all levels and in all social contexts. (UNESCO)

Big History has the potential to illustrate humanity's deep connections to each other, to the environment and even the universe itself. This is a critical first step towards sustainable thinking, a sense of connection. Our common roots go back to African savanna plains and to the big bang. We are not isolated individuals. What we do has consequences.

Big History books and pedagogy typically end with threshold 8, which discusses how the industrial age, fossil fuels, nuclear energy, population growth and modern technology have transformed the planet, accelerated our consumption of natural resources and tilted the environment out of balance. This situation is called the anthropocene by some and Big History takes the next step at the end of texts to call for some form of sustainability. In Christian's latest book, he specifically calls for adherence to Sustainable Development Goals (Origin Story, 292-3).

Sustainable development is succinctly defined in an oft-quoted report known as "Our Common Future" or the Brundtland Report as, "...development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED). The 2015 General Assembly of the United Nations adopted 17 Sustainable Development Goals (SDGs)

which cover: poverty, hunger, healthcare, education, gender equality, clean water, responsible consumption, climate action, etc., in the UN program, "Transforming our world: the 2030 Agenda for Sustainable Development" (UN, "SDG"). The vast and varying concerns towards the central goal of sustainability is a clear recognition of the systemic, transdisciplinary nature of sustainable development.

Clearly, creating a sustainable world civilization is not the job of one person or profession. Vast numbers of leaders with varying perspectives and talents will have to cooperate and support each other to accomplish this daunting goal. Within every SDG, there are multiple targets and indicators to help measure annual progress reports. Every human being, in my opinion, bears some moral responsibility to know these goals and contribute if and where they can. SDG 4 makes education a sustainability goal. "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" (Sustainable Development Goal 4). An essential component of this quality education will have to be how to think sustainably.

Big History is a meta-narrative about cosmic evolution from the big bang to the present day. I believe every step of the story is a tale about sustainability. I will make this case, one of my key points, in simple and more academic terms.

In simple terms, if we accept the Brundtland Report definition of 'taking care of today's needs without compromising the needs of others' tomorrow..,' every step of cosmic evolution, every threshold represents an observation of this rule. It is a basic survival prerogative. If any of these critical thresholds had robbed necessary resources for tomorrow to pay for today, humanity

would never exist or would have gone extinct. The universe has been generous or atleast benign with humanity so far. We're here.

Physicist and cosmic evolutionist Eric Chaisson makes this point more eloquently:

> Human beings and our cultural inventions are not special, unique, or apart from Nature; rather, we are an integral part of a universal evolutionary process connecting all such complex systems throughout space and time. Such evolution writ large has significant potential to unify the natural sciences into a holistic understanding of who we are and whence we came. No new science (beyond frontier, non-equilibrium thermodynamics) is needed to describe cosmic evolution's major milestones at a deep and empirical level. Quantitative models and experimental tests imply that a remarkable simplicity underlies the emergence and growth of complexity for a wide spectrum of known and diverse systems. Energy is a principal facilitator of the rising complexity of ordered systems within the expanding Universe; energy flows are as central to life and society as they are to stars and galaxies. ("Natural Science" 1)

Chaisson goes on to describe ascending orders of "energy rate density" as, "the amount of energy passing through a system per unit time and per unit mass." He continues, "In this way, neither new science nor mystical appeals to non-science are needed to explain the impressive hierarchy of complex systems in the cosmic-evolutionary narrative, from quarks to quasars, from microbes to minds" ("Natural Science" 9).

If we accept Chaisson's model, Big History, minus the 'mystical appeals,' is simply a sustainability story of increasing levels of system energy consumption while maintaining long-term environmental equilibrium (aka. complexity). Our sun, for example, is a large hydrogen fusion reactor that provides our planet with essential forms of light and heat energy and will continue to do so for another five billion years before its hydrogen fuel core begins to run out. So "sustainability" is relative. In terms of human time scales, the sun is a highly sustainable energy resource while on a universal scale, the sun is simply a short-term energy solution.

Back to Greta

Now, I return to 16 year old, Swedish climate activist, Greta Thunberg. The crisis for Greta and her generation of young adults entering higher education is a thoroughly discouraged and suspicious attitude towards the current establishment. On April 16, 2019, Greta addressed European Parliament Environment Committee and stated in her speech, "If our house was falling apart, you wouldn't hold three emergency Brexit summits and no emergency summit regarding the breakdown of the climate and the environment" (Rosane). She continued, "The extinction rate is up to six times faster than what is considered normal, with up to 200 species becoming extinct every single day. Erosion of fertile topsoil, deforestation of the rainforest, toxic air pollution, loss of insects and wildlife, acidification of our oceans — these are all disastrous trends" (Rosane).

Greta is neither the first nor perhaps the most shocking of the environmental alarmists. The Sierra Club formed and elected John Muir as their first president in 1892 (Sierra Club). The National Park Service was established in 1916 by President Woodrow Wilson, "to conserve the scenery and the natural and historic objects and wildlife therein, and to provide for the enjoyment

of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (Sutter 104). The first Earth Day was celebrated on April 22, 1970. The Environmental Protection Agency was established by President Nixon in 1970. Greenpeace was created in 1971 to protest nuclear testing and "ensure the ability of the Earth to nurture life in all its diversity" (Wikipedia Contributors, “Greenpeace”).

Many countries had begun earlier or established similar environmental organizations as the list of American ones noted above. 1972 marked the first global sustainability movement with the United Nations convening a Conference on the Human Environment in Stockholm. 1992 saw the first UN Earth Summit in Rio and the establishment of “Agenda 21,” a “comprehensive plan of action to be taken globally, nationally and locally by organizations of the United Nations System, Governments, and Major Groups in every area in which human impacts on the environment (Agenda21).

Since 1992, the international community has convened 12 major conferences which have committed governments to address urgently some of the most pressing problems facing the world today. Taken together, these high profile meetings have achieved a global consensus on the priorities for a new development agenda from the 1990s up to today (UN, Milestones). The United Nations Framework Convention on Climate Change, popularly known as the Paris Agreement, required a commitment from each member country to determine, plan, and regularly report on the contribution that it undertakes to mitigate global warming. This includes article 8 of the Agreement:

> Parties recognize the importance of integrated, holistic and balanced non-market approaches being available to Parties to assist in the implementation of their nationally determined contributions, in the context of sustainable development and poverty eradication, in a coordinated and effective manner, including through, inter alia, mitigation, adaptation, finance, technology transfer and capacity-building, as appropriate. These approaches shall aim to: (a) Promote mitigation and adaptation ambitions; (b) Enhance public and private sector participation in the implementation of nationally determined contributions; and (c) Enable opportunities for coordination across instruments and relevant institutional arrangements. (UNFCCC)

Signatories included President Barack Obama who stated, “"Even if we meet every target ... we will only get to part of where we need to go." He also stated, "this agreement will help delay or avoid some of the worst consequences of climate change. It will help other nations ratchet down their emissions over time, and set bolder targets as technology advances, all under a strong system of transparency that allows each nation to evaluate the progress of all other nations" (Obama). Eight months later, President Trump signaled he was withdrawing the United States from the Paris Agreement (Lipton).

The point I am attempting to make from the paragraphs above is that Greta Thunberg’s frustration is not unfounded. Environmental degradation and the environmentalist movements to address these crises have more than a century of academic, social and governmental recognition and action. Still, one of the first acts of the current president was to return to ignoring these

escalating problems. It would seem beyond all reason or tolerance. And yet, I don't recall much reaction to this decision and nothing has changed these policy decisions since. Nor is this one action completely out of character for our civilization. Many such reckless actions have taken place in the past.

As a country, as a civilization and as a human species, how do we not only recognize but address such stunning irresponsibility? How do we move beyond the denial we seem so entrenched within and inoculate ourselves, once and for all, from this destructive behavior? Education, I believe, must contribute.

At the end of her book, *Big History: From the Big Bang to the Present*, Cynthia Stokes Brown asks,

> Can we evolve culturally fast enough to make the transition to sustainability? Can we find a way to avoid a precipitous crash in our population? Can we make peace with Earth before it forces us into submission? If we wait until the data are unambiguously clear, our choices seem likely to be seriously compromised. What can propel humans to act before we are confronted with massive, immediate danger? (Stokes Brown 246)

The answer Greta's and Cynthia's concerns, I believe, lies in a serious commitment from education. Our evolution towards sustainability will require a paradigm shift in our manner of thinking. We have an undeniable commitment and responsibility to future generations. Denial of the future generation's rights to life and a high quality of life, equal to or better than our own,

constitutes immorality if not some serious crime. Our current thinking, our global consciousness have been demonstrated repeatedly to be inadequate to address this collective responsibility. We are currently a self-destructive species. Those who would leave important decisions about the future of humanity in the hands of irresponsible politicians need desperately to be reeducated.

Anthropocene

> This is the first time in the four-billion-year history of the biosphere that a single biological species has become the dominant force for change. In just a century or two, building on the huge energy flows and the remarkable innovations of the fossil-fuels revolution, we humans have stumbled into the role of planetary pilots without really knowing what instruments we should be looking at, what buttons we should be pressing, or where we are trying to land. This is new territory for humans, and for the entire biosphere. (Christian, *Origin Story* 259-260)

Big History is different from others history classes for many reasons. An important difference is a willingness to project into the future. In David Christian's *Origin Story*, Christian recognizes a new epoch in geological time, the Anthropocene. Sometime in the last one hundred or so years, reflected by the ecological movements mentioned previously, humanity became aware of the need for custodianship of natural resources and restrictions to human interaction with the environment. The pace of destruction continues to increase with every over-harvest and ecological disaster. We seem clearly unprepared to sustainably manage our impact on the planet. The idea that we have the option to ignore the problem clearly is self-destructive.

Reinhold Leinfelder, a member of the Anthropocene Working Group, writes that human beings must see themselves as integrated into nature and not separate from the ecosystem and unaffected by exploiting natural resources. Systemic, integrated thinking is a prerequisite for making any social contract for sustainability a reality. He writes, "Such systemic, transdisciplinary thinking will be essential for school, university, and professional education as well as for life-long learning, in order to not only understand the complexity of the ecospheric-anthropospheric system, but also to reflect, suggest, and initiate possible integrative options for action" (26).

There is no longer any choice. Humanity cannot wait for the planet to heal itself. Nor can we deny climate change and other serious impacts on the environment that sustains us. We must develop skills that help us recognize and address our impact as integrated and codependent stewards of our ecosystem. I think Systems thinking fits this requirement.

Systems Thinking

> Many of the issues that confront humanity and the planet today have a reach that transcends national borders and regional time frames. In order to solve such large-scale problems, today's citizens must develop the ability to see the issues at hand as inextricably linked within a large, complex global system.
>
> Systems thinking is crucial for solving complex, systemic problems and avoiding unintended consequences. It must become a core competency in twenty-first-century education. A large frame of reference is an essential ingredient for intellectual flexibility, as is an interconnected, interdisciplinary approach to the study of past and present complexities in our world. (Simon, et. al. 4)

From the Introduction to *Teaching Big History*

I was delighted to discover that some Dominican University faculty recognized systems thinking as a priority for 21st century education. This priority did not, however, make it into the expected educational outcomes of Dominican's view of a proper liberal education. This should be rectified. It is a specific and necessary skill.

While complexity remains an interesting but vague notion, a precursor to complexity, Systems Theory, is well-established. What makes systems thinking different from the potent but often inappropriate tool of reductionism can be explained in a few sentences or many books. To begin, systems thinking is a transdisciplinary process while reductionism tends to emphasize disciplinary boundaries. Systems thinking is more about the relationships *between* objects as a description of a system while reductionism attempts to disassemble the objects into discrete parts to describe the system (Seibert). Obviously, sometimes important qualities of a system are not reflected in the whole which led Aristotle, long ago, to state, "The whole is greater than the sum of the parts" (Metaphysics). Reductionism will always have a role in human thinking. But, to survive, we need to expand and evolve our thinking tools as a civilization.

In the simplest terms, one of the barriers to good systems thinking is this emphasis on connections between objects rather than on objects themselves. Objects are visible and usually easy to analyze. Connections are often invisible, abstract and variable. They are more difficult to analyze. If we thinking of a previous example of ant colonies, the individual ants are rather unremarkable. The behavior repertoire is basic. The interesting, complex and adaptable quality

of these ants is cooperative interrelationships between the ants. The hive mind is the hidden quality no one ant can demonstrate. It is something they collectively share. How exactly this works remains a mystery.

These subtle system qualities are often missed or ignored, sometimes at great cost. It is a serious problem, for example, that much climate change denial hinges on the observation that severe cold snaps occur. This is predicted by global warming models and presents absolutely no conflict nor contradiction. More serious is the specific oversight that O-rings on the space shuttle Challenger could be affected by climate. Or that falling home prices would lead to mass defaults on overextended subprime mortgages which failed mortgage-backed securities which connected to pension funds, mutual funds and corporations that depended on the health of these assets and caused the worst financial melt-down since the Great Depression. It was a systemic failure. No one dared to question how delicate the economy was while finance people are making good money. Alan Greenspan, chairman of the Federal Reserve, said no one could have foreseen the subprime mortgage crisis but that is precisely what Michael Burry at Scion Capital did. “I waited for the lenders to offer the most risky mortgages conceivable to the least qualified buyers. I knew that would mark the beginning of the end of the housing bubble” (Burry).

Caught between the financial predators in New York and the hedge fund gamblers in places like Cupertino were the masses of new home buyers looking for a deal too good to pass up. “Irrational exuberance” spread everywhere like a greedy virus. I’ve never met anyone who lost their farm in the Great Depression but I do know friends and coworkers who got caught up the housing bubble when it popped, abandoned their homes and their upside-down mortgages and

moved to other states to start over again. Technology and the internet have accelerated the rate at which false promises can be made. Our society needs protection before America ends up like other countries with two-tier societies, rich and poor. Sustainable cultures requires fair economic opportunities and education to protect people from unwise decisions. Systems thinking can help.

Application to Sustainability

It is possible to teach systems theory and systems thinking without reference to sustainability. It would be a huge disadvantage to attempt to teach sustainable principles and sustainability without systems thinking. Biological systems and the environment are open systems and a failure to recognize systems dynamics is precisely what many people believe has led to the many environmental and social problems raised in sustainability science.

While some percentage of schools in higher education have made sustainability a public priority, systems thinking is still not prioritized. It should be. It is not a completely new way of thinking, but it is more relevant to young adults than it ever has been. The Association for the Advancement of Sustainability in Higher Education (AASHE) states this clearly and succinctly:

> The fundamental problem faced in meeting the goal of education for a healthy and sustainable society for all students is that the existing curriculum in higher education has not been developed to examine how we shape a sustainable world. Much of the curriculum has been developed to provide students with an increasingly narrow understanding of disciplines, professions and jobs and is focused on specific knowledge and skills employed in the given area. What is needed is a curriculum that prepares learners for living sustainably, both

> professionally and personally, and that explicitly helps the learner deeply understand the interactions, inter-connections, and the consequences of actions and decisions.
>
> Regardless of the subject of the curriculum, students must learn and practice holistic systems thinking and be able to apply such thinking to real world situations. Furthermore, students must understand how the systems of which they are a part (social, economic, and ecological) function and are integrated. In order to accomplish this we need a significant segment of the learning opportunities for students to be structured to accomplish these outcomes. To do so will require significant changes in the curriculum and the pedagogy used to deliver that curriculum. (AASHE 2)

The AASHE then goes into how faculty, administrators and students can work together to facilitate a change in curricula, educational partnerships, workshops, accreditations, etc. These may or may not be useful. I am not a professor nor do I work in academia. I don't know what the top-down challenges are for transforming education. The perspective of this paper is a bottom-up approach to how education can improve response to the needs of students today. I think we need to expand the expectations of higher education beyond the capability to pay back student loans with lucrative jobs. This is short-term STEM thinking which I believe exacerbates our narrow minded thinking.

I want to conclude this paper not by leaving the reader to imagine if sustainability and systems thinking would be a proper conclusion to Big History or if such a suggestion is impractical. I believe it is better to leave the reader with one example to consider.

Pedagogical Example

Einstein said that problems cannot be solved by the same level of thinking that created them. We must evolve. The difficulty with complexity or even systems thinking is that it seems to be an arduous subject to learn. There appear to be difficult barriers. In fact, after I spent a little time researching, it became clear that systems thinking and sustainability would not be difficult to learn. It makes sense to start with the basics which are rather intuitive and straightforward.

MIT Systems Thinking Professor, Barry Richmond said there are two activities involved in system thinking: constructing mental models and then simulating them in order to draw conclusions and make decisions (2). In systems thinking, the modeling often comes in the form of stocks and flows diagrams (See fig. 1). Systems thinking pioneer and MIT research fellow Donella Meadows said, "If you understand the dynamics of stocks and flows—their behavior over time—you understand a good deal about the behavior of complex systems. And if you have had much experience with a bathtub, you understand the dynamics of stocks and flows" (19).

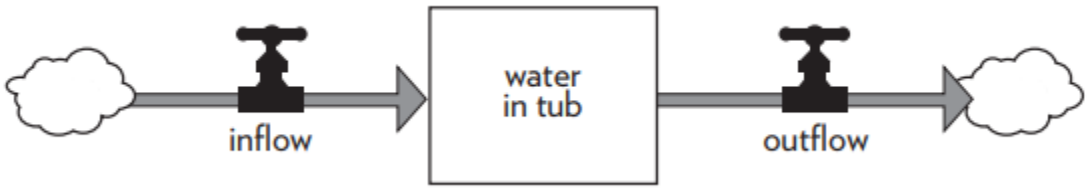

Figure 1 Simple Stock and Flow Diagram

The one example I want to end with is an example of systems thinking starting with a real ecosystem and then create the abstract model to help think about the system ***as*** a system.

Most people, if they have read Steinbeck or are generally aware of Cannery Row, know that the sardines were fished out of Monterey Bay in the 1950's, never to return. The whole town and the local industry collapsed due to unsustainable practices. People assume that it was simply overfishing that led to the economic and ecological disaster but the actual story is a bit more intricate and complicated.

A Very Short Big History of the Pacific Sardine Fishery

Sardines are one of the most robust and productive fisheries in the world. They are an important part of the ecosystem and land, sea and air creatures depend on them. Pacific sardine populations have boom and bust years as a natural occurrence. Warm pacific currents off the central California coast, which are rich in plankton nutrients, lead to high spawning years. Cold currents push the sardine spawn down to the Sea of Cortez where nutrients are sparse. These are down years (see fig. 2). These variations in current temperatures when matched with World War 2 deregulation of the sardine stocks led to unchecked overfishing and left fewer yearlings (sardines live 5 or more years and spawn after a year) to spawn in down years with cold currents that drove sardines to low nutrient waters. The 1950's recorded huge drops in sardine catch, year after year. Studies were conducted by local, state and federal organizations to examine the problem. Studies performed in central and northern California showed drastic drops in sardine stocks. Southern California studies showed stable or increasing populations (which is expected during down years but ignores the migratory patterns). The State, presented with apparently conflicting reports, decided to open the fishery to large catches of sardines during repeated down

years and almost wiped the population out. The Pacific sardine fishery was closed from the 1960s to the 1980s when it finally recovered (Parrish).

Some Important System Factors:

Annual Catch (Harvest Amount in Tons)

Cold Currents (La Niña)

Warm Currents (El Niño)

External Events (WW2)

Local & State Politics (Regulations on harvest)

Industry Influence (Fishermen and Canneries)

Geography - California Sardine Industry was caught between cold and warm variations.

Ignorance of the Sardine Ecosystem

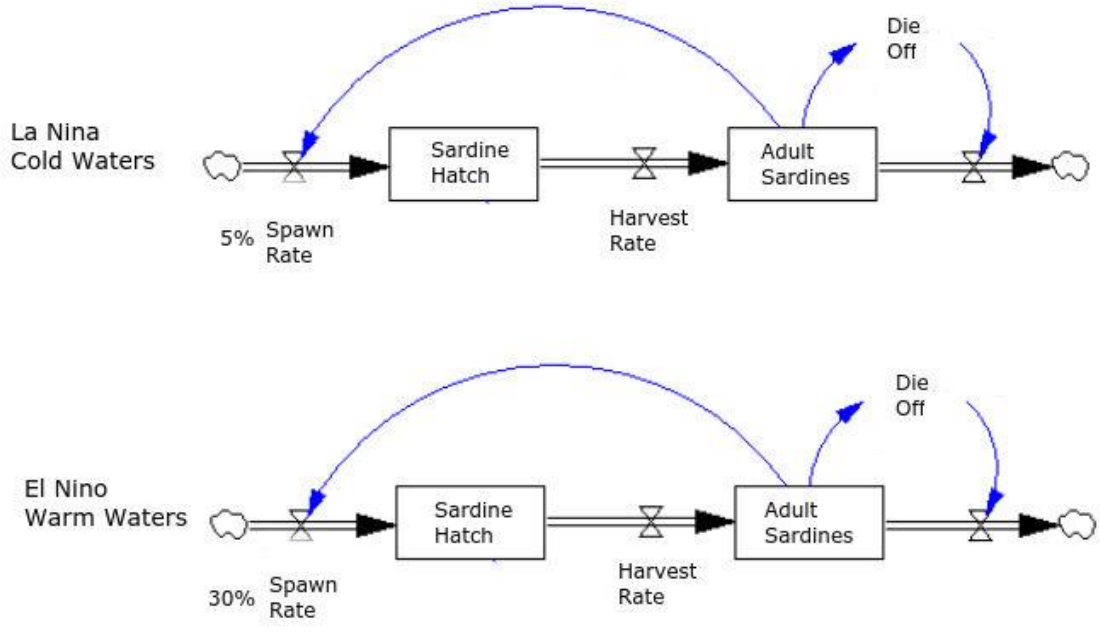

Figure 2 Stock and Flow Diagram of Pacific Sardine Ecosystem

The stock and flow diagrams clearly show spawn rates as the critical factor which should have determined harvest rates as a percentage of estimated total stock biomass (Adult Sardines). There are other factors in the system. The die off may affect predators or plankton spawns. More or less hatched sardine larvae may reach reproductive maturity depending on factors like cold and warm currents. These factors were not considered. But, in this simple example, it is clear that sustainable fisheries should harvest less than 5% in cold years and less than 30% of the total stock in warm water years.

This type of experience offers an opportunity to gather data of a real system in nature and then review it as an system abstraction for discussion and focus. This systems thinking unit could continue with a design thinking group exercise where students can **empathize** with fisherman, consumers, environmentalists, legislators, all the people involved and affected by sardine harvest rates. Then they can **ideate** as a group and cooperate to suggest sustainable solutions to the situation (Lake, et. al.).

This example was not suggested to the reader to demonstrate the full power of systems thinking nor to impress with complicated nuances of systems theory. I offer this example to show how even the dimensions of a simple systems are often overlooked and have had devastating consequences. This is a practical example which I think students can easily understand.

Sustainability, Sustainable Design, Systems Thinking, Design Thinking are all related skills which depend on the holistic view Big History adequately introduces. Globalism, the internet, pervasive mobile technology, social media and crowdsourcing make these skills not only

relevant but requirements for current and future jobs. Complexity is still a developing, theoretical science, but its precursor, systems thinking, has useful and approachable tools that can help students begin their journey towards non-reductive thinking and a better appreciation of our world's systemic nuances.

CONCLUSION

I credit David Christian and other big historians as well as Mojgan Behmand and the Dominican University staff for the audacity of trying to bring a grand narrative back to school against the political tide of contemporary higher education. I think they've tried to solve a particular problem of bringing meaning and big questions back to education after a long absence. Big History bravely brings back the big questions. But I believe too little attention may have gone into what students think (or need). But this can be corrected.

Meaning is a deeply personal issue and unscientific. There is no scale or formula for meaning. The subject is highly subjective. I found the Big History narrative compelling and I discovered an alignment with myth like the Eternal Return and Monomyth described by Eliade and Campbell. I also found the introduction of complexity to the creation of our universe interesting and possessing a ring of truth even if the details have not been completely worked out. But it is not until Sustainability is added that the circle in a sense is completed, a wholeness is achieved and the recurring theme of increasing levels of complexity begins to hold some real kind of meaning and consequence.

Sustainability at the earliest stages of creation is about balance, harmony and supporting foundations for higher levels of creation. Sustainability at a human level signifies a kind of essential altruism which aligns with the Brundtland report about 'meeting current needs without compromising the ability of future generations to meet their own needs.' But every threshold holds some story about how individual and collective needs are met. Every level of complexity, I believe, is a story about sustainability.

I have explained how I believe sustainability is the lesson of Big History. It is the moral of the story. It ***is*** the meaning. After students are introduced to level after level of a universe that is finely tuned and delicately balanced to sustain ever increasing flows of energy, a critical point or climactic juncture occurs. Students should consider whether they, as individuals and as a civilization, are exempt from nature's laws or if they are an integral piece of the picture (with all the responsibilities and restrictions implied therein). One might call this religious, theological, moral, ethical or just survivalist. They are presented with difficult choices about what kind of world they support, what kind of leaders they will elect and what kind of people they want to be.

Such delicate innerwork or contemplation only takes place when engaged deeply in myth, religion, science or philosophy. These deep, rich questions force students to find their own meaning. Or, as John Haught put it, "A really Big History must take into account the interior dimension of living…"(2).

While I am critical of the tone of naturalism and scientism found in Big History, I remain very optimistic and excited about the future of programs like the First Year Experience at Dominican University. I would rather see staff adjust a program rather than abandon it entirely. That seems wasteful. There is deep potential to offer something profound and enriching that transforms students' self-awareness while it expands their knowledge of the universe and prepares them for rewarding engagement in the 21st century. Programs like Big History, which invite life's big questions and culminate in important subjects like sustainability afford students the opportunity to fully exercise their minds and improve their self-awareness as well as their vocational potential.

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